Surface-Only Flux Algorithm Report

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Background (Page 1)

CERES uses several surface-only flux algorithms to compute SW and LW surface fluxes in conjunction with the detailed model used by SARB. These algorithms include:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

References:

SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.

SW B: Darnell et al. (1992): *J Geophys. Res.*, **97**, 15741-15760.

Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.

LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.

LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.

LW C: Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.

SOFA: Kratz et al. (2010): *J. Appl. Meteor. Climatol.*, **49**, 164-180.

SOFA: Gupta et al. (2010): *J. Appl. Meteor. Climatol.,* **49**, 1579-1589.

Background (Page 2)

- The SOFA LW & SW Models are based on rapid, highly parameterized TOA-to-surface transfer algorithms to derive surface fluxes.
- LW Models A & B as well as SW Model A were incorporated at the start of the CERES project.
- SW Model B was adapted for use in the CERES processing shortly before the launch of TRMM.
- The Edition 2B LW & SW surface flux results underwent extensive validation (See: Kratz et al. 2010), and can be used to provide independent verification of the SARB results.
- The ongoing validation process has already led to improvements to the LW models (Gupta et al., 2010).
- LW Model C will be introduced in Edition 4 processing to maintain two independent LW algorithms after the CERES Window Channel is replaced in future versions of the CERES instrument.

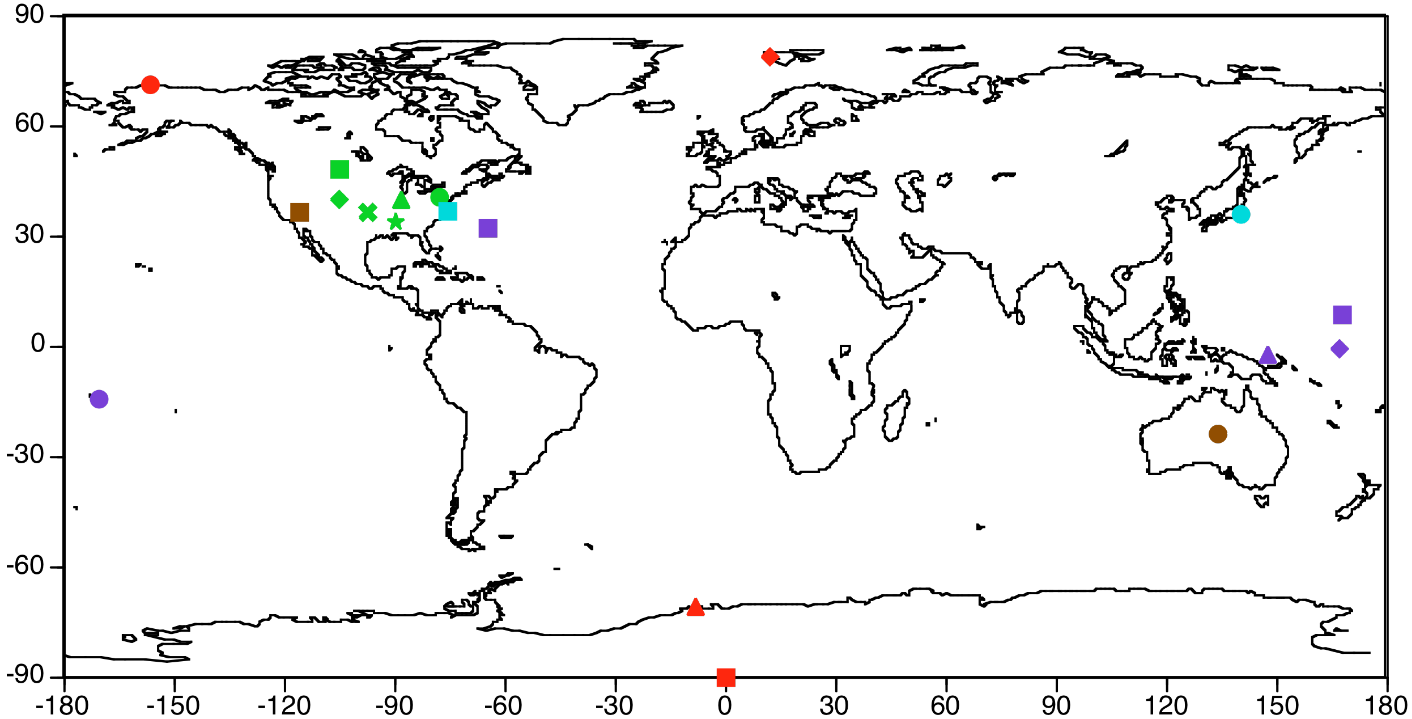
Recent Improvements to the Surface-Only Flux Algorithms

SW Model Improvements: 1) Replacing the ERBE albedo maps with Terra maps greatly improved the SW retrievals, most notably for polar regions. 2) Replacing the original WCP-55 aerosols properties with the MATCH/OPAC data while also replacing the original Rayleigh molecular scattering formulation with the Bodhaine et al. (1999) formulation significantly improved SW surface fluxes for clear conditions. 3) Using a revised empirical coefficient in the cloud transmission formula improved the SW surface fluxes for partly cloudy conditions.

LW Model Improvements: 1) Constraining the lapse rate to 10K/100hPA (roughly the dry adiabatic lapse rate) improved the derivation of surface fluxes for conditions involving surface temperatures that greatly exceeded the overlying air temperatures, see Gupta et al. (2010). 2) Limiting inversions to a maximum of 10K/100hPa for the downward flux retrievals provided the best results for cases involving surface temperatures that were much below the overlying air temperatures (strong inversions).

Parameterized models for fast computation of surface fluxes for both CERES and FLASHFlux

Dataset	CERES 2B	CERES Terra 4A
Clear-Sky TOA albedo Terra	48 month ERBE	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	70 month Terra
Clear-Sky Surface albedo	46 month Terra	70 month Terra
TOA to surface albedo transfer	Instantaneous	Monthly average
Cos (sza) dependence of Surface Flux	Original LPSA	Briegleb-type
SW aerosol dataset	WCP-55	MATCH/OPAC
Rayleigh Treatment	Original LPSA	Bodhaine et al (1999), JAOT.
Ozone Range Check	0 to 500 DU	0 to 800 DU
Cloud transmission empirical coefficient	0.80	0.75
LW high temperature surface correction	No	Yes
LW Inversion correction	No	Yes



- 48.31N, 105.10W Fort Peck, MT
- 40.72N, 77.93W Penn State, PA
- 40.05N, 88.37W Bondville, IL
- 40.13N, 105.24W Boulder, CO
- 34.25N, 89.87W Goodwin Creek, MS
- 36.60N, 97.48W SGP ARM
- 32.30N, 64.77W Bermuda

- 8.72N, 167.72E Kwajalein
- 14.23S, 170.56W American Samoa
- 2.06S, 147.42 E Manus
- 0.52S, 166.9 E, Nauru
- 36.05N, 140.13E Tatano
- 36.9N, 75.71W CLH

- 71.32N, 156.61W Barrow, AK
- 90.00S, 0.00 South Pole
- 70.65S, 8.25W Georg von Neumayer
- 78.9N, 11.95E Ny Alesund
- 23.70S, 133.87E Alice Springs
- 36.63N, 116.02W Desert Rock, NV

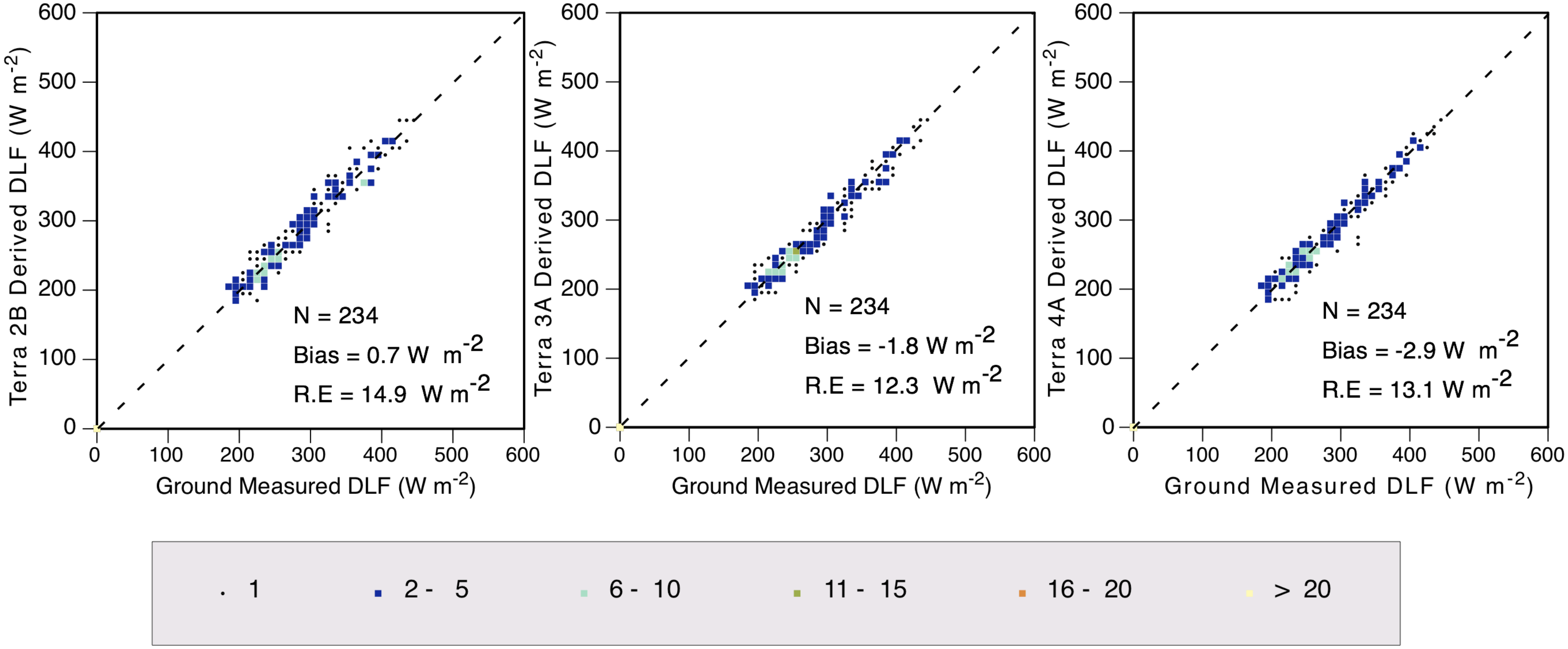
CERES 2B/(T2G,A2D)/3A/4A and FLASHFlux 2G

	C2B		C3A	C4A	
Dataset	CERES 2B	CERES 2D/2G	CERES 3A	CERES Terra 4A	FLASHFlux 2G
GEOS Version	4.0.3	5.2.0	4.0.3 / 5.2.0	5.4.0	5.2.0 instantaneous
MODIS Collection	4	5	5	5	5
Spectral Corr. Coef.	CERES 2B	CERES 2D/2G	CERES 3A	CERES 3A	FLASH Version 4
Ozone Cutoff	500 DU	None	None	None	None
Clear-Sky TOA albedo Terra	48 month ERBE	48 month ERBE	70 month Terra	70 month Terra	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	46 month Terra	70 month Terra	70 month Terra	70 month Terra
Clear-Sky Surface albedo	46 month Terra	46 month Terra	70 month Terra	70 month Terra	70 month Terra
TOA to surface albedo transfer	Instantaneous	Instantaneous	Monthly average	Monthly average	Monthly average
Clouds Algorithm Terra	Terra Ed2	Terra Ed2	Terra Ed2	Terra/Aqua Ed4	Modified Terra Ed2
Clouds Algorithm Aqua	Aqua Ed2	Aqua Ed2	Aqua Ed2	Terra/Aqua Ed4	Modified Aqua Ed2
SW aerosol dataset	WCP-55	WCP-55	WCP-55	MATCH/OPAC	WCP-55
Rayleigh Treatment	LPSA	LPSA	LPSA	Bodhaine et al (1999), JAOT.	LPSA
NSIDC	1/8 mesh	1/8 Mesh	1/8 mesh	1/8 mesh	1/16 mesh
Cos (sza) dependence of Surface Flux	LPSA	LPSA	Briegleb-type	Briegleb-type	Briegleb-type
Terminator (Twilight polar/non-polar clouds algorithm)	old	Old	old	new	new
Cloud a0 coefficient	0.80	0.80	0.80	0.75	0.80
LW high temperature surface correction	No	No	Yes	Yes	Yes
LW Inversion correction	No	No	Polar regions and ps < 700mb excluded	Maximum Inversion limited to 10 K	No
ADM	Terra Ed2B	Terra Ed2B	Terra Ed2B	Terra Ed4	Terra Ed2B

Comparison between CERES Terra Editions 2B, 3A and 4A

LW Model A code changes from Editions 2B through 3A to 4A include constraint methods to 1) limit lapse rates to 10K/100hPa to prevent unrealistic lower layer temperatures and 2) limit inversions to 10K.

Clear-Sky 60°S to 60°N



November 2000 through January 2001 and May 2001 through July 2001

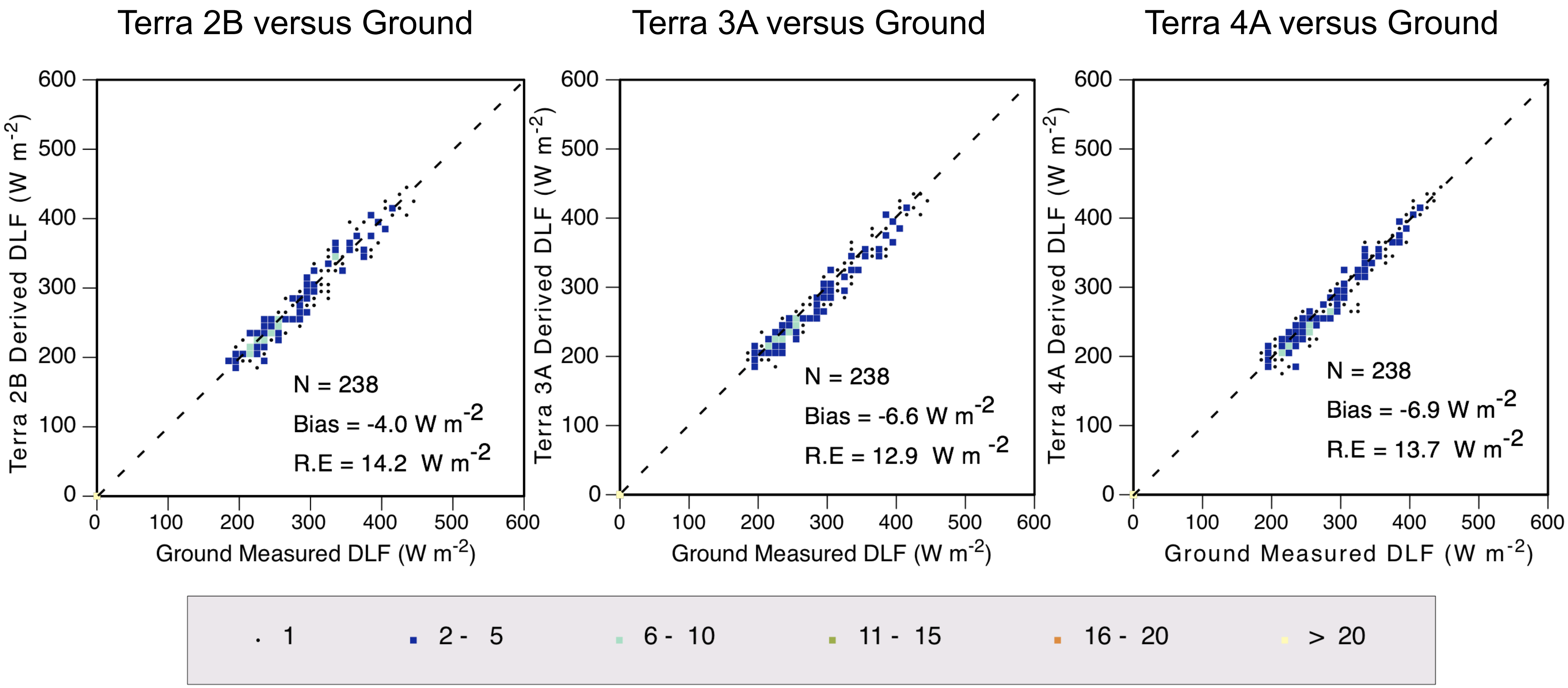
Includes input differences

Climate Science Branch, NASA Langley Research Center

Comparison between CERES Terra Editions 2B, 3A and 4A

LW Model B code changes from Editions 2B through 3A to 4A include constraint methods to 1) limit lapse rates to 10K/100hPa to prevent unrealistic lower layer temperatures and 2) limit inversions to 10K.

Clear-Sky 60°S to 60°N



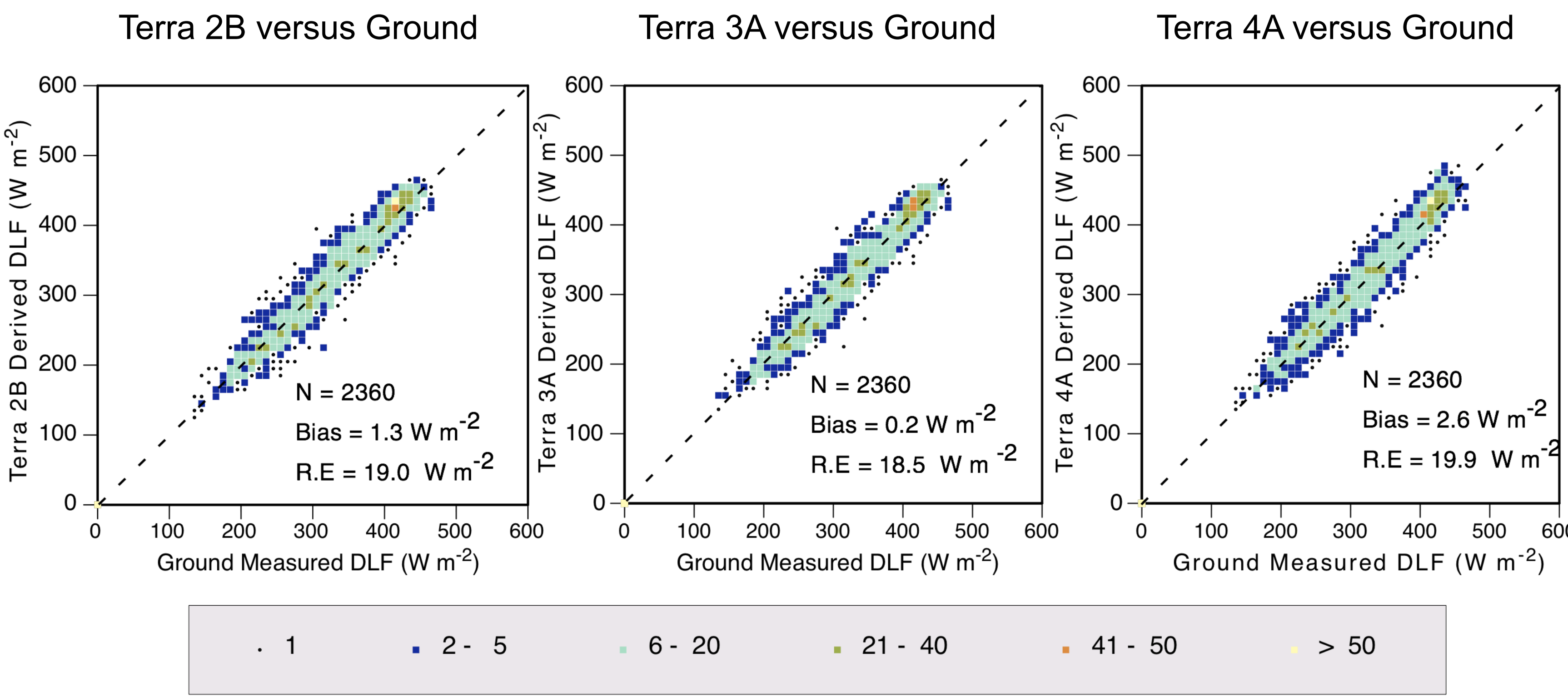
November 2000 through January 2001 and May 2001 through July 2001

Includes input differences

Comparison between CERES Terra Editions 2B, 3A and 4A

LW Model B code changes from Editions 2B through 3A to 4A include constraint methods to 1) limit lapse rates to 10K/100hPa to prevent unrealistic lower layer temperatures and 2) limit inversions to 10K.

All-Sky 60°S to 60°N



November 2000 through January 2001 and May 2001 through July 2001 — Includes input differences

Climate Science Branch, NASA Langley Research Center

Results of Recent LW Model Improvements

To improve upon the accuracy of the LW Models, methods have been formulated to constrain the near-surface air temperature for the downward flux calculations to allow for the effective management of two extreme conditions in LW Models A, B & C:

1) For the condition involving surface temperatures that greatly exceed the overlying air temperatures, constraining the lapse rate to 10 K/100 hPA (roughly the dry adiabatic lapse rate) has significantly improved the results, see Gupta et al. (2010).

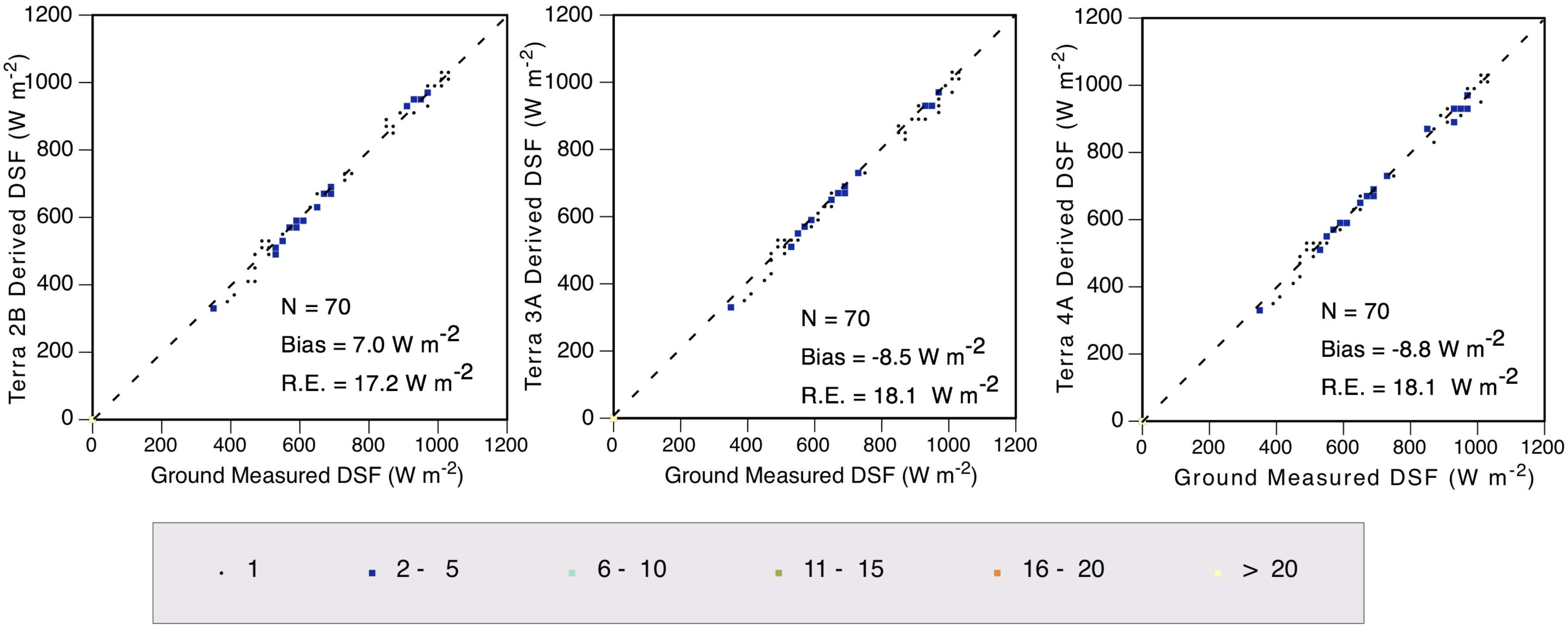
2) For conditions involving surface temperatures that are much below the overlying air temperatures (strong inversions), limiting the inversion to a maximum of 10 K/100 hPa for the downward flux calculations provides the best results for all conditions, including the high altitude, low water vapor cases seen during the winter at the Antarctic Plateau. For these cases, the air temperatures immediately above the surface are not representative of the atmospheric emission to the surface.

Comparison between CERES Terra Editions 2B, 3A and 4A

There were no SW Model A code changes, only changes to the input albedo maps and aerosols, from Editions 2B through 3A to 4A.

Clear-Sky 60°S to 60°N

Terra 2B versus Ground | Terra 3A versus Ground | Terra 4A versus Ground



November 2000 through January 2001 and May 2001 through July 2001

Includes input differences

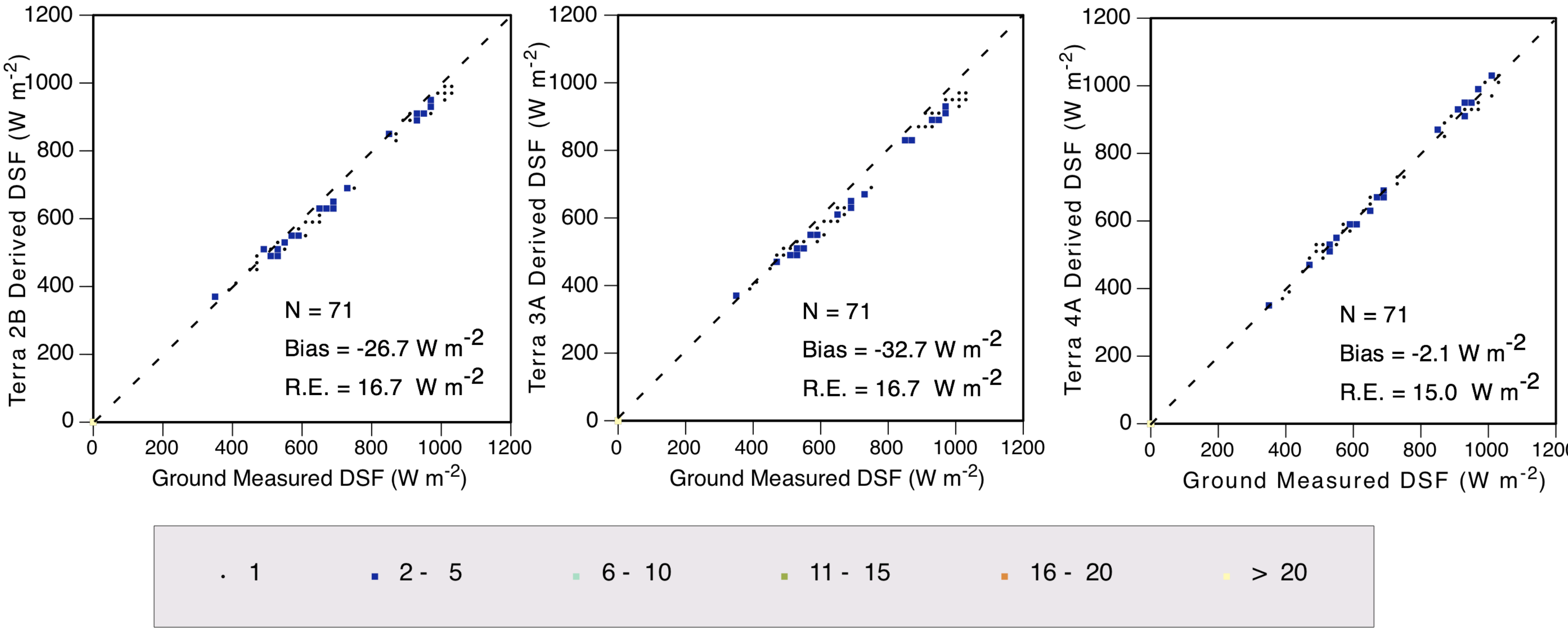
Climate Science Branch, NASA Langley Research Center

Comparison between CERES Terra Editions 2B, 3A and 4A

SW Model B code changes from Editions 2B through 3A to 4A include replacing the input albedo maps and aerosols, the Rayleigh molecular formulation, and the cloud transmission coefficient.

Clear-Sky 60°S to 60°N

Terra 2B versus Ground Terra 3A versus Ground Terra 4A versus Ground



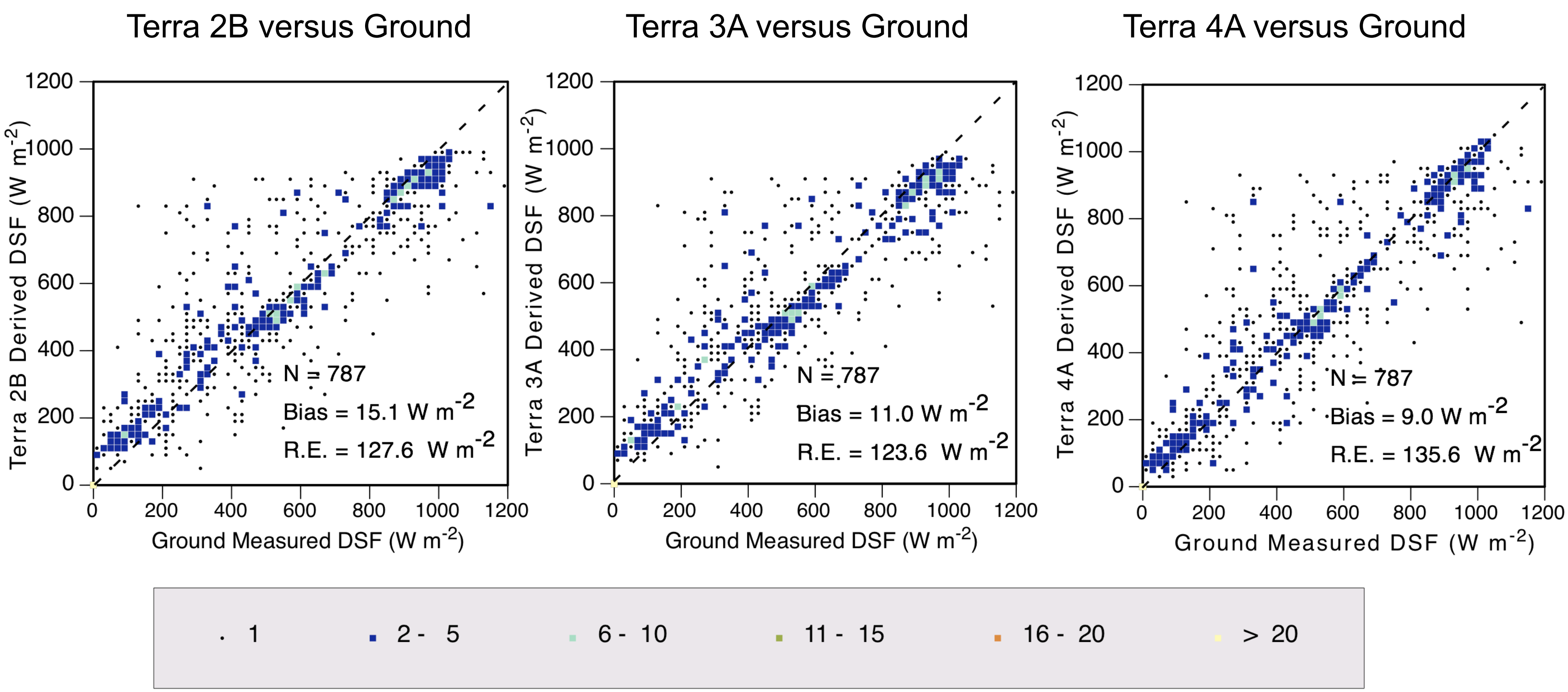
November 2000 through January 2001 and May 2001 through July 2001 Includes input differences

Climate Science Branch, NASA Langley Research Center

Comparison between CERES Terra Editions 2B, 3A and 4A

SW Model B code changes from Editions 2B through 3A to 4A include replacing the input albedo maps and aerosols, the Rayleigh molecular formulation, and the cloud transmission coefficient.

All-Sky 60°S to 60°N



November 2000 through January 2001 and May 2001 through July 2001

Includes input differences

Climate Science Branch, NASA Langley Research Center

Results of Recent SW Model Improvements and Course of Action for the Future

Simultaneously replacing the original WCP-55 aerosols with the MATCH aerosols, and the original Rayleigh molecular scattering formulation with an improved Rayleigh molecular scattering formulation has significantly improved the surface SW flux calculations for clear through partly cloudy sky conditions.

Results for the mostly cloudy to overcast conditions strongly suggest that further work on the cloud transmittance calculation is necessary. Our attention is currently focused on the formulae used for the cloud transmittance and the overcast albedo.

To account for the short term variability of aerosol properties, we plan to examine the feasibility of incorporating the daily aerosol properties into SW Model B.

CERES 2B/(T2G,A2D)/3A/4A and FLASHFlux 2G

			C3A		F2G
Dataset	CERES 2B	CERES 2D/2G	CERES 3A	CERES Terra 4A	FLASHFlux 2G
GEOS Version	4.0.3	5.2.0	4.0.3 5.2.0	5.4.0	5.2.0 instantaneous
MODIS Collection	4	5	5	5	5
Spectral Corr. Coef.	CERES 2B	CERES 2D/2G	CERES 3A	CERES 3A	FLASH Version 4
Ozone Cutoff	500 DU	None	None	None	None
Clear-Sky TOA albedo Terra	48 month ERBE	48 month ERBE	70 month Terra	70 month Terra	70 month Terra
Clear-Sky TOA albedo Aqua	46 month Terra	46 month Terra	70 month Terra	70 month Terra	70 month Terra
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TOA to surface albedo transfer	Instantaneous	Instantaneous	Monthly average	Monthly average	Monthly average
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SW aerosol dataset	WCP-55	WCP-55	WCP-55	MATCH/OPAC	WCP-55
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Cos (sza) dependence of Surface Flux	LPSA	LPSA	Briegleb-type	Briegleb-type	Briegleb-type
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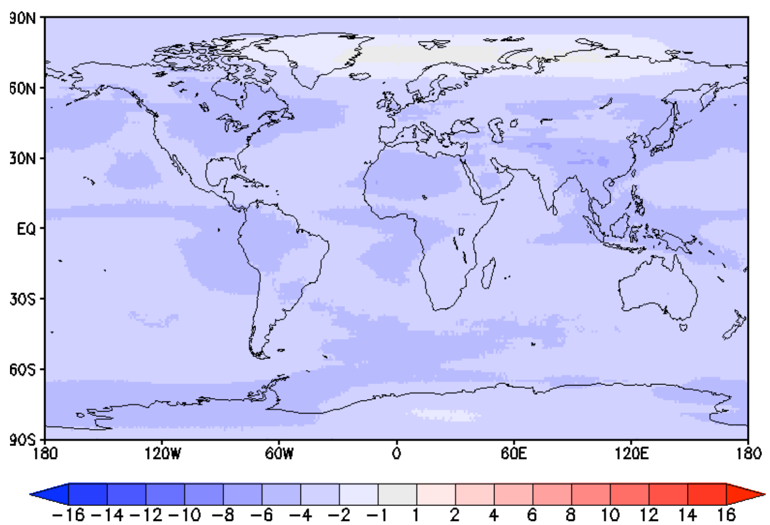
Cloud a0 coefficient	0.80	0.80	0.80	0.75	0.80
LW high temperature surface correction	No	No	Yes	Yes	Yes
LW Inversion correction	No	No	Polar regions and ps < 700mb excluded	Maximum Inversion limited to 10 K	No
ADM	Terra Ed2B	Terra Ed2B	Terra Ed2B	Terra Ed4	Terra Ed2B

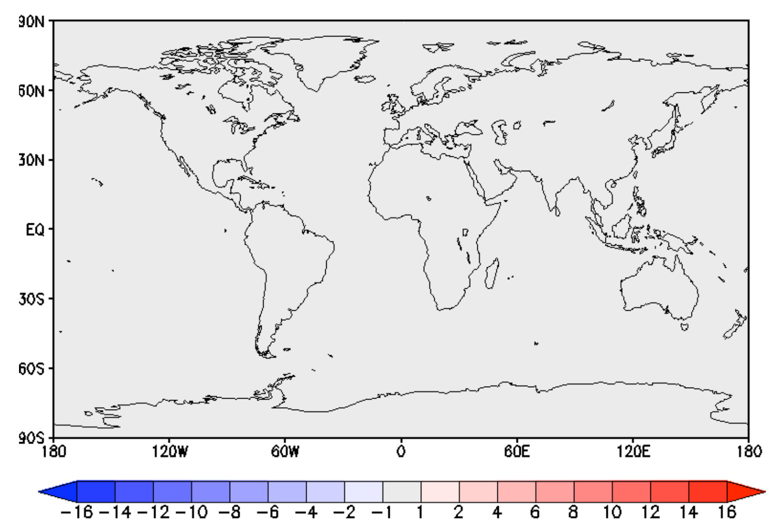
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave TOA annual mean day and night fluxes derived from Terra measurements for the overlap year of 2009.

The differences in the the Terra LW TOA day are due to the modest (of order 1 W/m^2) changes to both the LW & SW portions of the Total channel SCC (Spectral Correction Coefficients), to a very small change to the SW channel SCC, and to Clouds inputs.

FLASH-CERES LW TOA Diff Day 2009



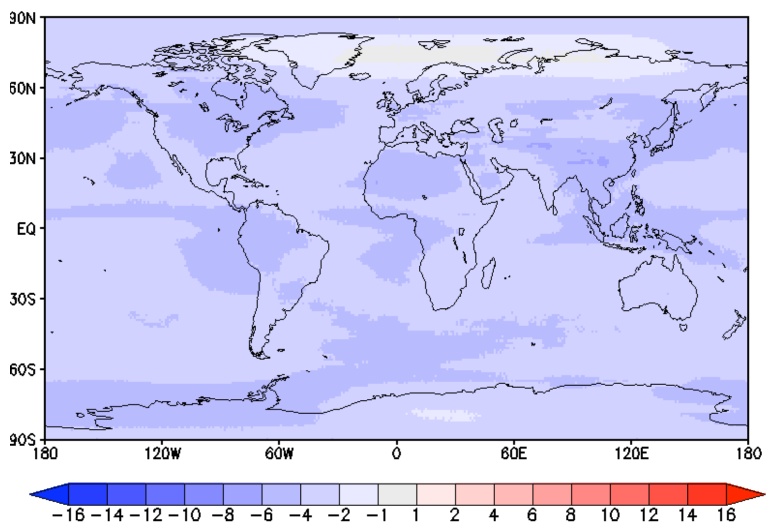
FLASH-CERES LW TOA Diff Night 2009



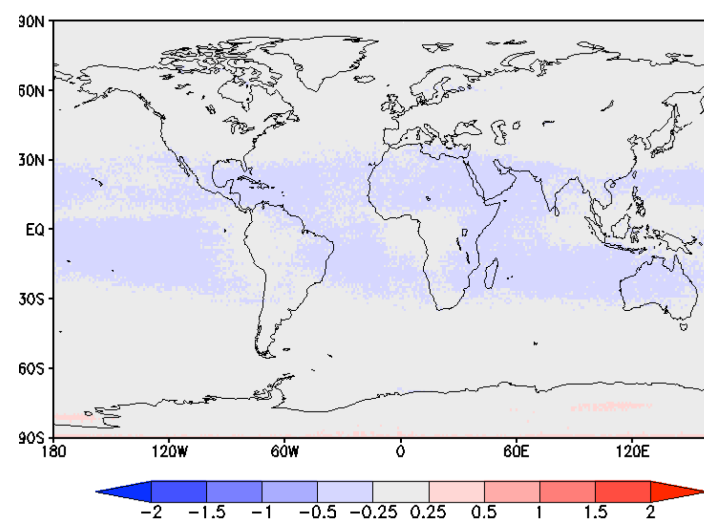
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave TOA annual mean day and night fluxes derived from Terra measurements for the overlap year of 2009.

The smaller differences in the the Terra LW TOA night are due to modest (of order 1 W/m^2) change to only the LW portion of the Total channel SCC, and to Clouds input. Note the scale difference between LW TOA day and night.

FLASH-CERES LW TOA Diff Day 2009



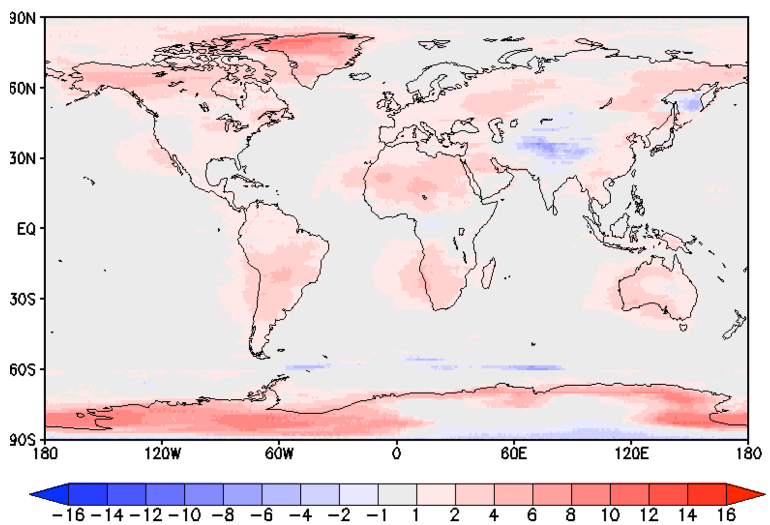
FLASH-CERES LW TOA Diff Night 2009



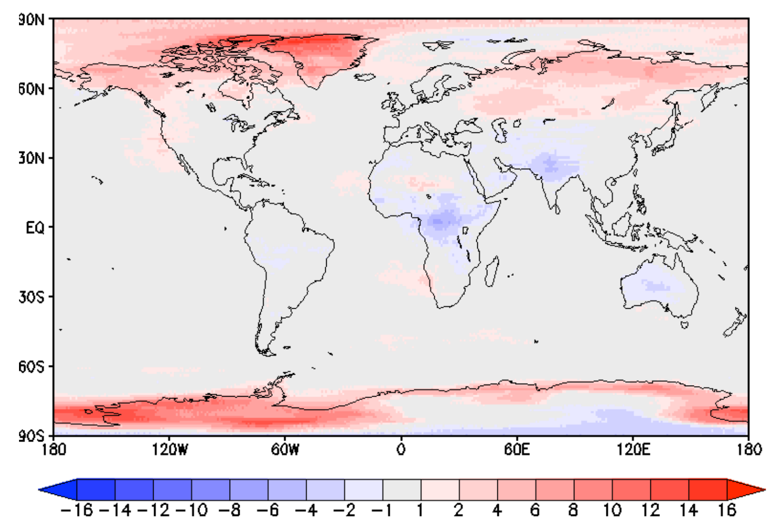
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave Surface annual mean day and night fluxes derived from Terra measurements for the overlap year of 2009.

The LW algorithm assumes that the TOA and surface fluxes are decoupled. Hence, TOA differences are not transferred to the surface. Changes in the inputs (e.g., Clouds and GEOS 5.2.0 data) and the algorithm (T_s) are responsible for differences.

FLASH-CERES LW Surf Diff Day 2009



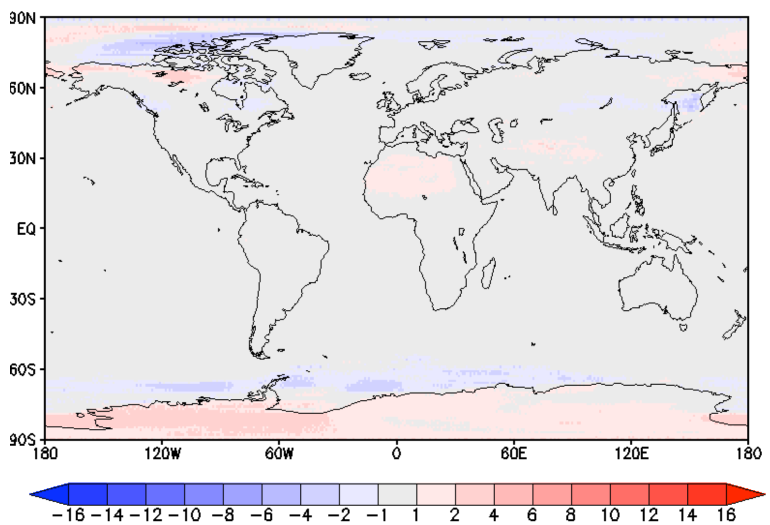
FLASH-CERES LW Surf Diff Night 2009



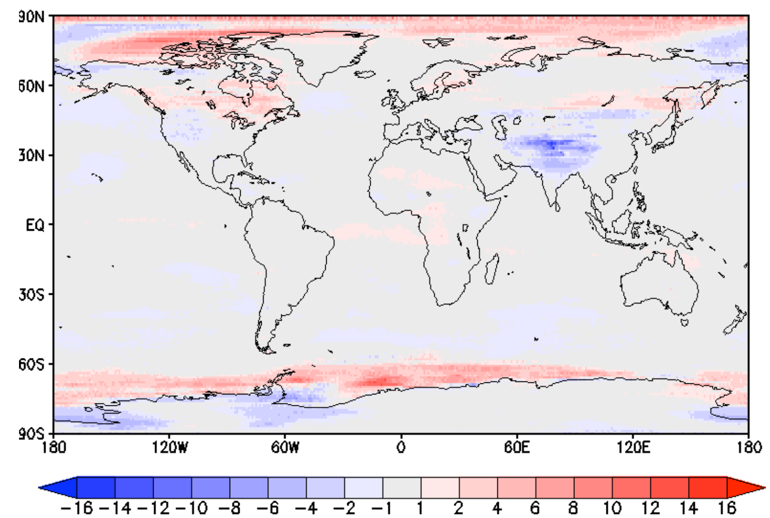
Comparison between the FLASHFlux Version 2G and CERES Edition 3A shortwave TOA and Surface annual mean day fluxes derived from Terra measurements for the overlap year of 2009.

The lack of a significant systematic differences in the the Terra SW TOA & surface day is due to the very small change in the SW channel SCC. Changes in inputs from Clouds cause most of the differences.

FLASH-CERES SW TOA Diff Day 2009



FLASH-CERES SW Surf Diff Day 2009

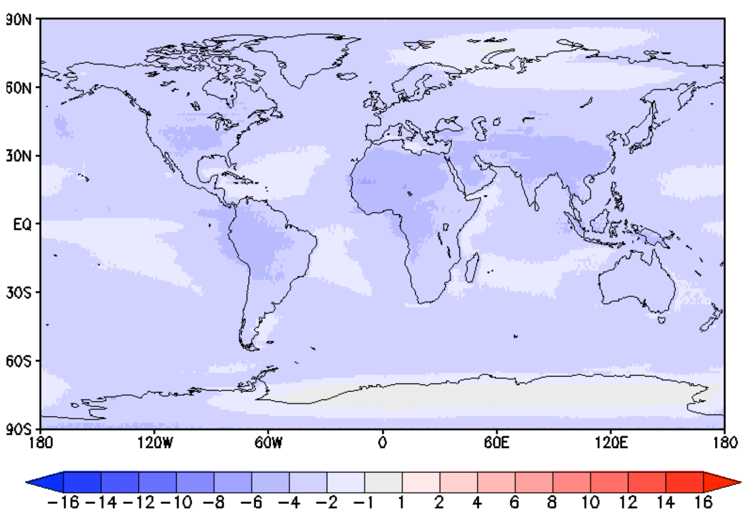


Note: The differences in the Surface fluxes are the inverse of the TOA fluxes

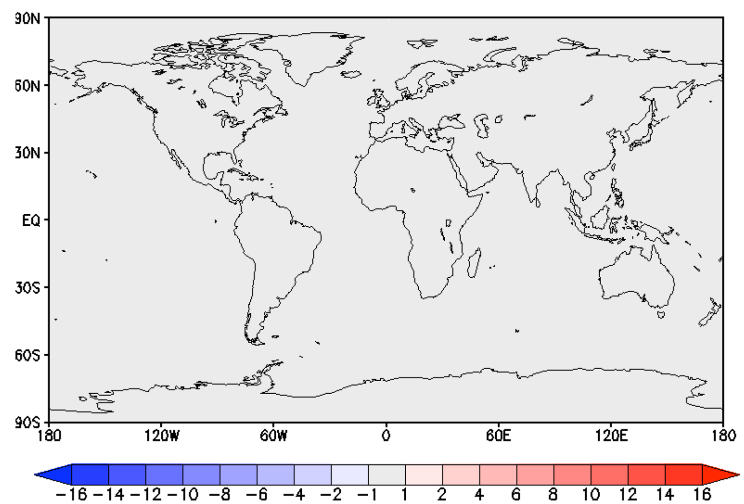
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave TOA annual mean day and night fluxes derived from Aqua measurements for the overlap year of 2009.

The difference in the the Aqua LW TOA day is due to the modest (1 W/m^2) change to the LW portion of the Total channel SCC and larger (of order 2 to 3 W/m^2) changes to the SW portion of the Total Channel and the SW channel SCCs, and Clouds inputs.

FLASH-CERES LW TOA Diff Day 2009



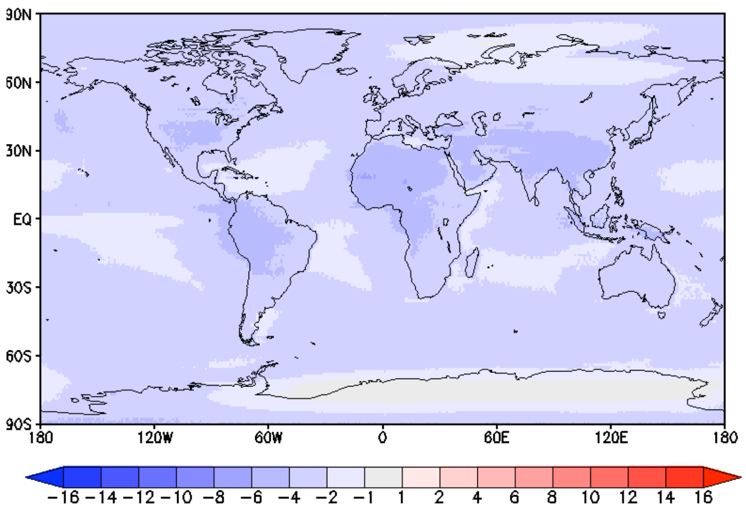
FLASH-CERES LW TOA Diff Night 2009



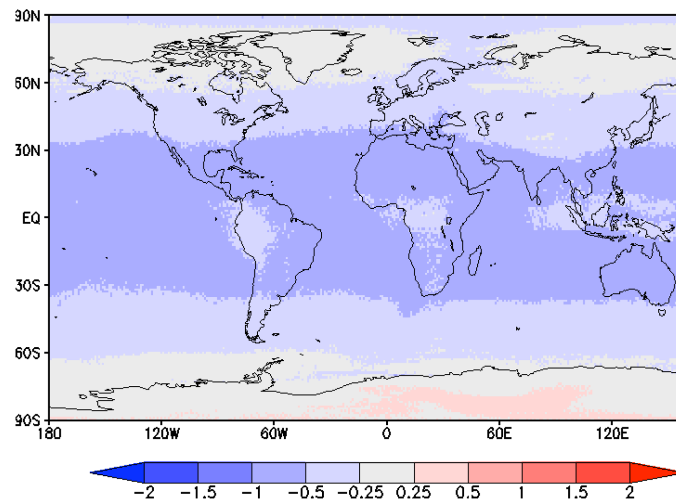
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave TOA annual mean day and night fluxes derived from Aqua measurements for the overlap year of 2009.

The smaller differences in the the Aqua LW TOA night are due to modest (of order 1 W/m^2) change to only the LW portion of the Total channel SCC, and to Clouds input. Note the scale difference between LW TOA day and night.

FLASH-CERES LW TOA Diff Day 2009



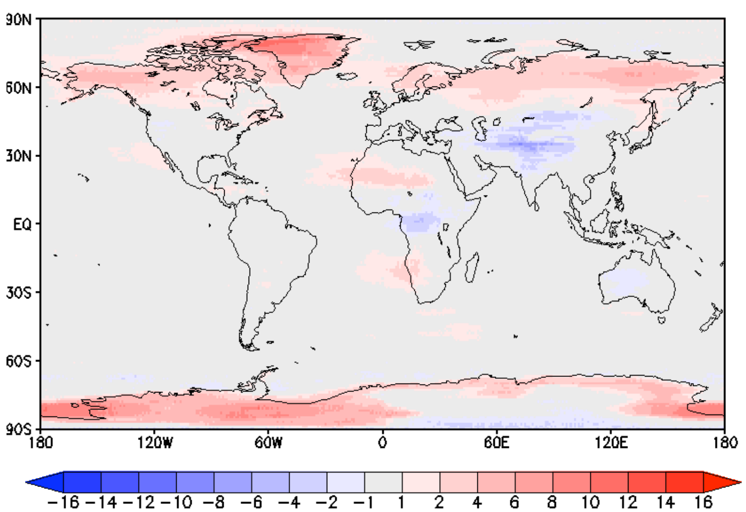
FLASH-CERES LW TOA Diff Night 2009



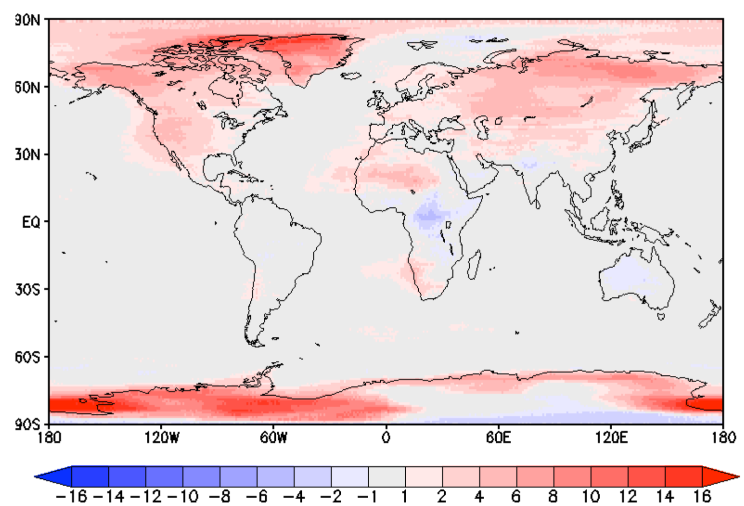
Comparison between the FLASHFlux Version 2G and CERES Edition 3A longwave Surface annual mean day and night fluxes derived from Aqua measurements for the overlap year of 2009.

The LW algorithm assumes that the TOA and surface fluxes are decoupled. Hence, TOA differences are not transferred to the surface. Changes in the inputs (e.g., Clouds and GEOS 5.2.0 data) and the algorithm (T_s) are responsible for differences.

FLASH-CERES LW Surf Diff Day 2009



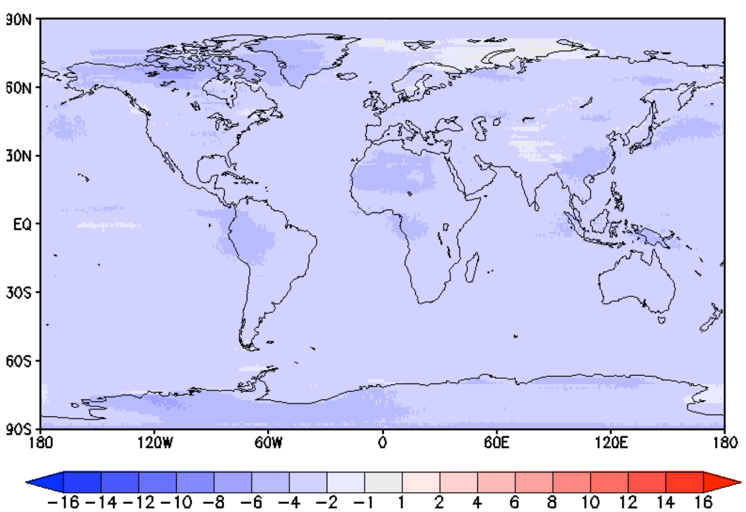
FLASH-CERES LW Surf Diff Night 2009



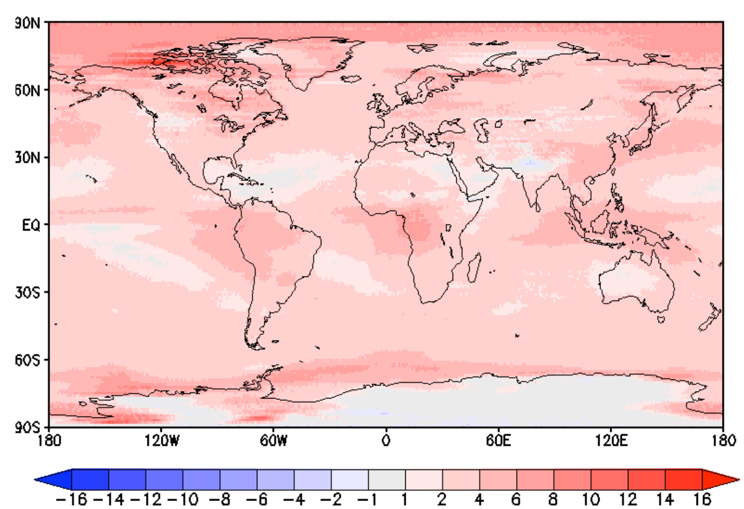
Comparison between the FLASHFlux Version 2G and CERES Edition 3A shortwave TOA and Surface annual mean day fluxes derived from Aqua measurements for the overlap year of 2009.

The systematic difference in the the Aqua SW TOA & Surface is mostly due to the big (of order 2 to 3 W/m^2) change in the SW channel SCC. Changes in inputs from Clouds cause most of the other differences.

FLASH-CERES SW TOA Diff Day 2009



FLASH-CERES SW Surf Diff Day 2009



Note: The differences in the Surface fluxes are the inverse of the TOA fluxes

CERES Journal Publication Citations

For all publications whether funded by CERES or using CERES data, please include the word "CERES" in the keyword list as this will facilitate listing your publication in the CERES formal publication web-page list (http://ceres.larc.nasa.gov/docs.php).

When any paper, technical report, or book chapter has either been accepted for publication or been published, please notify the CERES group of this publication by contacting Anne Wilber at (anne.c.wilber@nasa.gov).

CERES Journal Publication Citation Values (1/1/2011)

Year	All References	Journal Articles	c1 Citation	c2 Citation	c3 Citation
2010	71	56	49	1112	2315
2009	48	47	222	1049	2183
2008	62	61	406	995	2071
2007	39	28	229	678	1411
2006	44	40	910	523	1089
2005	49	47	1090	519	1080
2004	39	39	890	361	751
2003	51	48	1187	402	837
2002	78	69	3347	291	606
2001	50	44	1560	199	414
2000	34	32	879	173	360
1999	24	21	612	141	294
1998	20	20	1584	77	160
1997	9	9	265	52	108
1996	5	5	573	52	108
1995	1	1	17	20	42
1994	1	1	3	13	27
1993	6	6	33	0	0
Total	631	574	13856	6657	13856

Citation c1 = # of citations for papers published in that year.

Citation c2 = # of citations for papers published in all years using a specified set of categories.

Citation c3 = renormalized # of citations for papers published in all years so that the total number of citations in c3 = c1